aa txfonts epsfig graphicx times

document

Chandra and XMM–*Newton* observations of Tololo 0109-383 G. Matt1, S. Bianchi1, M. Guainazzi2, W.N. Brandt3, A.C. Fabian4, K. Iwasawa4 G.C. Perola1

Giorgio Matt

Dipartimento di Fisica, Università degli Studi Roma Tre, Italy XMM-Newton Science Operation Center/RSSD-ESA, Villafranca del Castillo, Spain Department of Astronomy and Astrophysics, 525 Davey Laboratory, Pennsylvania State University, University Park, PA 16802, U.S.A. Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, U.K.

Received / Accepted

G. Matt et al.

We present and discuss *Chandra* and XMM-*Newton* observations of the Seyfert 2 galaxy and Compton–thick absorbed source, Tololo 0109-383. The hard X–ray emission (i.e. above ∼2 keV), is dominated by a spatially unresolved reflection component, as already discovered by previous ASCA and BeppoSAX observations. The soft X–ray emission is partly (∼15%) extended over about 1 kpc. Below 2 keV, the spectrum is very steep and two emission lines, probably due to recombination to He–like ions of oxygen and neon, are clearly present. Combining X–rays and optical information taken from the literature, we propose an overall scenario for the nuclear regions of this source. galaxies: individual: Tololo 0109–383 - galaxies: Seyfert - X-rays: galaxies

Introduction

Tololo 0109–383 (a.k.a. NGC 424) is a remarkable obscured Seyfert galaxy. It was classified as a Seyfert 2 by Smith (1975). Boisson & Durret (1986) discovered weak broad Hα and Hβ lines. Broad lines were also observed in polarized light (Moran et al. 2000), the polarization degree being, after correction for starlight, about 4%. Murayama et al. (1998) studied the optical spectrum in detail and, besides confirming the presence of broad Hα and Hβ lines in direct light, also discovered Fe ii emission, and a partially extended (about 1 kpc) High Ionization Nuclear Emission Line Region (HINER), 70% of which was however unresolved ($\lesssim$ 200 pc). HST/WFPC2 data showed the presence of a dust lane across the central part of the galaxy (Malkan et al. 1998), which may help to explain the observed A_V ∼1.4 to the NLR (Murayama et al. 1998; it corresponds to $N_H \sim 3 \times 10^{21}$ cm^{-2} for a dust–to–gas ratio equal to that of the Galactic ISM).

In X–rays, Collinge & Brandt (2000) analysed ASCA data and, based on the prominent iron line, the flat spectrum, and the large [O iii]/F(2-10 keV) ratio, argued that the nucleus of Tololo 0109–383 should, rather surprisingly given its optical appearance, be absorbed by Compton–thick matter. This result was fully confirmed by BeppoSAX (Matt et al. 2000; Iwasawa et al. 2001), which measured the absorbing column to be about 2×10^{24} cm^{-2}. The estimated nuclear 2–10 keV luminosity is about 10^{43} erg s^{-1}. The IRAS colours are quite warm, suggesting that the IR emission is dominated by dust reprocessing of the nuclear radiation (Matt et al. 2000).

In this paper we present *Chandra* and XMM–*Newton* observations of Tololo 0109–383. The superior perfomances of these satellites permit us to study the source spectrum down to 0.3 keV and to search for extended emission.

Assuming H_0=70 km s^{-1} Mpc^{-1}, the redshift of the source, z=0.0117, corresponds to a distance of 48.5 Mpc. At this distance, 1 corresponds to 235 pc.

Observations and Data Reduction

Chandra

Chandra observed Tololo 0109–383 on February 4, 2002, with ACIS–S in standard configuration and with a 0.8 s frame time, to reduce pile–up to negligible values. After data reduction, performed with CIAO v.2.2.1, the exposure time is 9181 s.

XMM–Newton

XMM–*Newton* observed the source on December 12, 2001. Both EPIC cameras were operated in full–frame mode, as at the flux level expected for the source pile–up is negligible. The data were reduced with SAS 5.3.3, and using a Calibration Index File generated at the time of the analysis, August 15, 2002. Only events corresponding to patterns 0-4 and 0-12 were used for the p-n and MOS, respectively. Events from the two MOS cameras were merged to obtain a single event file. The background in both instruments remained constant during the observation. After data reduction, the exposure times are 4525 s for the p-n, and 7538

s for the MOS.

Data Analysis

The data were binned in order to have at least 25 counts per bin, to ensure applicability of χ^2 statistics, and to oversample the energy resolution by a factor 3. They have been analyzed with xspec.v11.1. Errors correspond to the 90% confidence level for one interesting parameter ($\Delta\chi^2$=2.7).

Chandra

Spatial analysis

The image is dominated by a point–like source coincident, within the *Chandra* angular resolution, with the optical nucleus (see Fig. chimage). However, emission extended over about 5 is also apparent (Fig tol$_e xt$).$Thisemissionisabout13\%(17\%)ofthetotalfluxinthe0.3-10(0.3-2)keVenergyband, anditissomewhatasymmetr$

figure figure=h4047f1.ps,width=100mm The *Chandra* 0.3-7 keV isophotes superimposed on the HST image. chimage